PHOTOGRAPHS OF SNOW CRYSTALS.

MR. W. A. BENTLEY, of Jericho, Vermont, U.S.A., has devoted twenty years to the study of snow crystals, with special reference to the relation between their forms and the atmospheric condition at the time of their fall. He gives in the U.S. *Monthly Weather Review* a short account of the results of his investigations; and a number of beautiful reproductions of photo-micrographs of snow crystals secured by him, accompany his paper. By the courtesy of Mr. Willis L. Moore, chief of U.S. Weather Bureau, we are able to give several of these pictures and an abstract of Mr. Bentley's contribution referring to them. So far as we are aware, no more beautiful or complete collection of photographs of snow crystals has ever been obtained than that produced by Mr. Bentley's patient work, and the fact that he has prosecuted his studies in somewhat difficult circumstances for so long is an excellent testimony to his scientific enthusiasm. We understand that he is preparing a volume upon the photographs, and the results of his studies of them. An album containing prints of all his drawings and photographs, with a short description of the methods and conclusions, would certainly be of great scientific value. The following notes are abridged from his paper in the *Monthly Weather Review*.

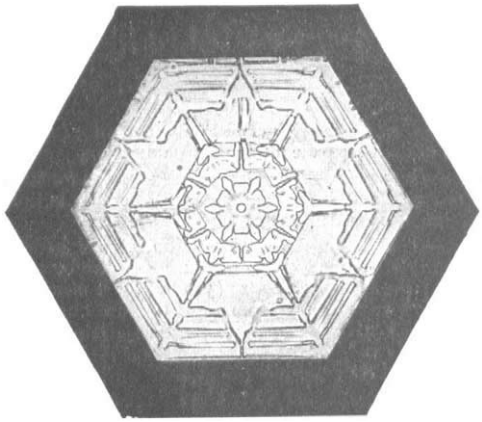

FIG. 1.—1895, February 8. Wind north-west, temperature −4° F.

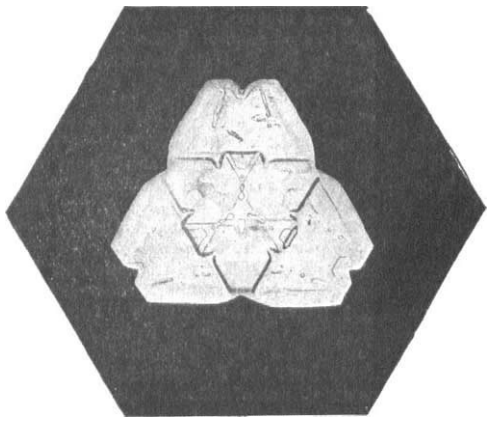

FIG. 2.—1900, February 18. Wind west to north-west, temperature 11°.

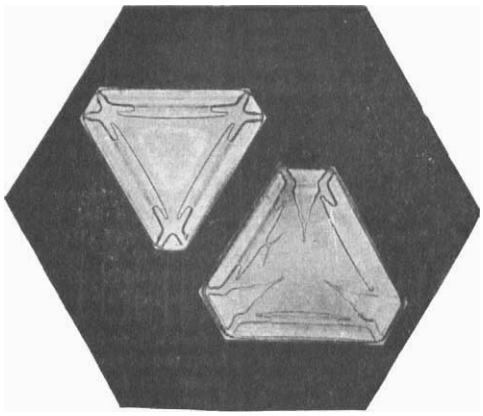

FIG. 3.—1899, February 13. Wind north, temperature 1°.

Photographs have been secured during every winter since 1884, and they now number more than 800, no two alike. Nearly every great and famous winter storm since that date has furnished its quota of from four to twenty (and in one instance thirty-four) of new forms to this collection. At the same time, observations have been made and data secured, while photographing them, of the temperature; kinds and approximate heights of clouds (when possible); the direction and rapidity of movement of various cloud strata; the direction and velocity of the surface winds; also changes in the forms of the crystals form hour to hour as the different portions of each storm passed over the district. The latter observations were made to ascertain whether there was any general law of distribution of the forms within the different portions of a storm. Differences in form of crystals deposited by local storms from those of general storms were also noted, as also

FIG. 4.—1900, December 5. Wind north-west to north, temperature 22°. Cloud, stratus.

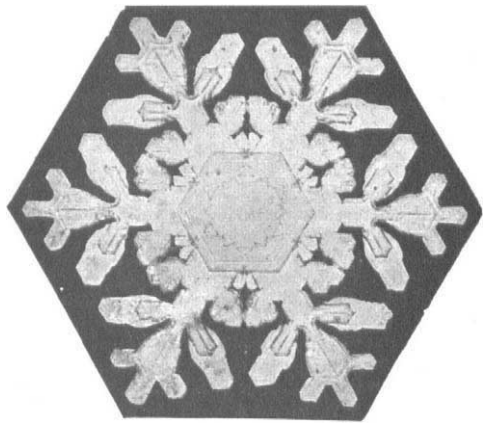

FIG. 5.—1888, March 12. Great blizzard, temperature 12°. Diameter one-quarter of an inch.

the forms originating in, and peculiar to, each of the various cloud strata. These observations, and the data secured, indicate that the temperature and the humidity of the air at the earth's surface is a much less important factor than is generally supposed in determining the form and size of the crystals. We may easily conceive this to be the case, because at a given temperature, &c., at the earth's surface, the temperature and humidity of the air where the crystals form might vary greatly, one time from another, and would depend largely upon the height of the snow-producing clouds. The height of these varies greatly at different times, even when the temperature at the earth's surface remains the same. The data secured have not revealed the great mystery of the origin and cause of the differences in the forms of the nuclei; why columnar forms predominate at one time, tabular forms at another, or why both are sometimes found associated together. Much has been learned, however, of the conditions tending to modify their forms after the nuclear form is once organised. These conditions are many, the chief among them being the height, number and vertical depth of the cloud strata and the resultant variation in temperature, atmospheric pressure and humidity due to these; the character of the storm, whether local or general, and the portion of the storm region from which the crystals come. To these must also be added the initial and subsequent movement of the crystals within the clouds. If, as must often be the case, the nuclear forms originating in the lower ascending clouds are carried upward to much greater heights by the strong ascending air currents, which often occur within such storms, until they become heavy enough to fall back through them, then the crystals will in all probability be greatly modified by passing through atmospheric strata varying greatly in density, temperature, humidity, &c. That they are greatly modified by these flights in the clouds is clearly shown by the interior structure of many of the crystals outlining many of these transitory states. Thus, crystals of which the nuclear form was originally nearly perfectly hexagonal sometimes become partly triangular in outline, and *vice versâ*. No. 8 is an example of such modifications.

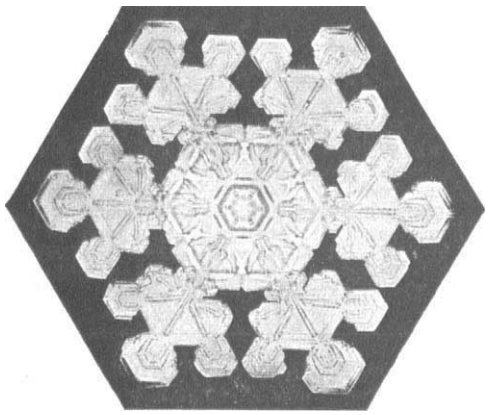

FIG. 6.—1901, February 15. Wind north-west, temperature 14°.

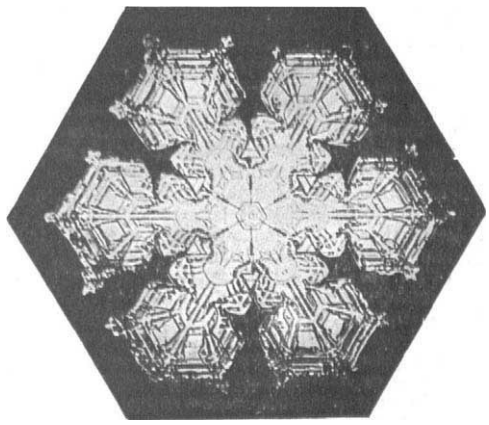

FIG. 7.—1898, January 26. Wind changing west to north-west, temperature 18°.

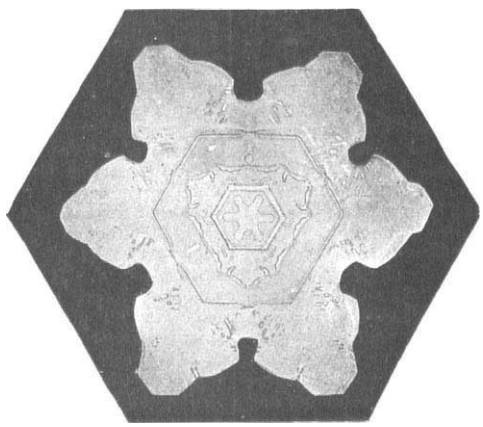

FIG. 8.—1899, January 6. Wind south-south-east, temperature 22°. Clouds, upper stratus.

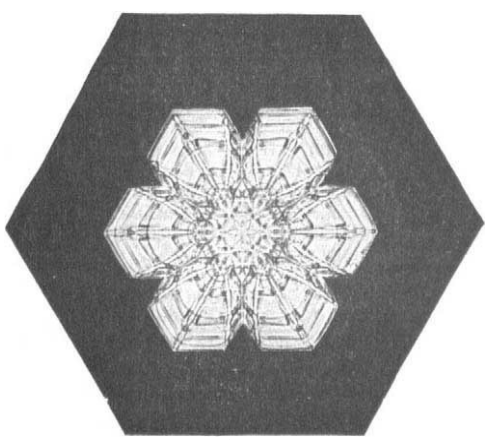

FIG. 9.—1886, February 26. Wind north-west, temperature 8°.

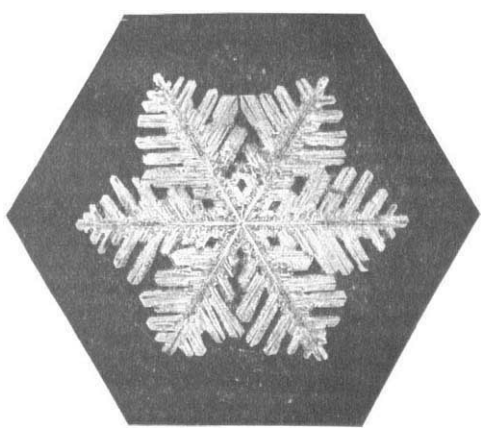

FIG. 10.—Wind west, temperature 34°.

Perhaps the most important facts of a general nature to be gleaned from twenty years' study are these:

(1) That the greater number of the more perfect and beautifu tabular forms occur much more frequently in, and are confine

almost wholly to, the western and north-western portions of great storms and blizzards.

(2) That there seems to be a law of general distribution of the different forms, the columnar to one, the tabular and granular to others, with many varieties associated together in other portions of such great storms.

(3) That this distribution is, with few exceptions, constant, that is, the same in nearly all storms.

Sufficient data has not as yet been collected to demonstrate beyond all doubt the fact that this law applies to all forms of crystals and to all storms alike.

Passing on to the variation in form of those crystals deposited by local storms, as compared with those of general storms, we find that these are very marked, except during intense cold.

The local storm types and those precipitated from low, detached clouds usually consist of large, frail, branching, tabular forms, devoid of a solid tabular nucleus (see No. 10), or of heavy granular varieties, similar one to the other, each according to its class. On the other hand, those deposited by general storms are usually more diversified in form and more complex in structure, the snowfall often consisting of two or more varieties associated together. The larger and more perfect columnar prisms, columnar forms possessing tabular outgrowths at one or both ends (which we might call doublets), truncated triangular forms (see Nos. 2 and 3), and solid tabular forms, the latter often possessing wonderfully beautiful and complex interior designs (as in No. 1), are common only to general storms. Branching tabular and granular forms are common to both general and local storms, but they ordinarily possess solid nuclei if deposited from a general storm (as in Nos. 4–7), whereas the nuclei are generally absent (as in No. 10) if the crystals originated in local storms. During zero weather the crystals of local storms approach much nearer in form to those of general storms, and we find solid tabular forms, branching tabular forms possessing solid hexagonal nuclei and sometimes doublets, among the snowfall. Often during the intense cold succeeding a blizzard the snowfall will consist wholly of very minute columnar and pyramidal forms, or of both columnar and minute frost-like tabular forms, falling apparently from low, detached nimbus or alto-nimbus clouds, or even from a sky free, or nearly so, of clouds.

During relatively mild temperatures each cloud stratum, if alone, there being no other clouds either above or below them, commonly precipitates each its own peculiar type of crystals. Low detached nimbus clouds deposit large, frail, branching tabular forms, similar to No. 10; intermediate clouds, smaller, branching tabular forms, possessing solid hexagonal nuclei; and the high cirro-stratus clouds, small compact columnar and tabular forms. The large cumulus clouds of spring and autumn usually shed large, heavy, pyramidal-shaped granular snow. These granular forms frequently, if not invariably, possess nuclei of branching, tabular forms, and are usually precipitated when the temperature is near or somewhat above the freezing point.

Of the photomicrographs which accompany this article all, with the exception of No. 10, are those common to and were deposited by great storms.

Of the other numbers of the series, No. 2 is very rare and unusual, containing as it does eleven triangular divisions within its outlines. Apparently the lines of greatest growth were reversed during one stage of the growth of this strange form, thus differing widely from No. 3, which has outlines somewhat similar. No. 4 possesses a very rare unique nuclear design which is very difficult to explain by any process of crystallisation of which we know. No. 5 (a souvenir of the great blizzard of March 12, 1888) is very symmetrical, as also is No. 6, of February 15, 1901. No. 7 is, in all but the unimportant outermost points, a marvel of complexity and perfect symmetry. No. 9 is also a marvellously beautiful and symmetrical example of snow architecture.

Passing to the causes governing the formation of the nucleus, whether it be columnar or tabular, the electrified state of the atmosphere, whether negative or positive, and perhaps, also, as suggested by Prof. Cleveland Abbe, the presence in greater or less amounts of various gases and vapours in the atmosphere, may all be controlling factors.

Although much has been already learned about these interesting phenomena, yet there still remains much more. Cooperation between many observers is essential to carry out this work successfully. Simultaneous observations of the forms and changes the crystals undergo from hour to hour during our great blizzards should be made by many skilled observers, stationed along a general line extending north and south. These observers must be familiar with the names and approximate heights of the various clouds. This study should include observations of the kind and approximate height and direction of drift of the various clouds, direction and force of the surface wind, temperature of the air, and amount of moisture at the earth's surface; also its electric condition, whether negative or positive, and the portion of the storm from which the crystals emanate.

It is also highly desirable that observations be made to ascertain why the perfect crystals are more common in the western portion of storms, and also why certain portions produce certain types.

Such a study, supplemented by investigations as to the causes of the formation of the two fundamental types of hoar-frost crystals, would doubtless lead to the discovery of very many of the mysteries surrounding the origin and history of the wondrously beautiful forms of snow.

A NEW JOURNAL OF ANATOMY.

THE first number of a new scientific magazine—*The American Journal of Anatomy* (Baltimore, November 1901)—has been received and merits a descriptive notice because, as it has been "founded to collect into one place, and present in a worthy manner, the many researches" of American anatomists, it marks a new departure in scientific journalism, and while its pages are but 98 in number we are informed that future issues will be in quarterly parts of about 125 pages each. The interest with which British anatomists regard their branch of science as practised in America has during the last four to five years been heightened by the association, as joint editor of our own long-established *Journal of Anatomy and Physiology*, of Prof. G. S. Huntington, of the Columbia University at Washington, who is one of the chief promoters of the new journal now under review. The reason of this enhanced interest lies in the fact that his connection with the English publication was marked by the appearance in its pages of a paper of a kind to which its readers were unaccustomed. It deals with a series of sections of an early human embryo, and while containing nothing that is new, surpasses all precedent in being illustrated by 11 plates of photomicrographic figures which do not portray a single fresh fact and can only be defined as useless. When, further, it is observed that the paper (by an English author) which immediately followed this in order of publication was similarly granted 12 plates, where 4 might well have sufficed, there is no wonder that there arose in the minds of the supporters of the journal a misgiving, lest the new association might perhaps lead to disaster. Let it be said, however, that American papers since received have been of a more normal kind.

This consideration lends interest to the circumstance that in the journal under review one of the five papers submitted monopolises 37 of the 98 pp. which make up the issue, as well as the whole of the 9 plates and 27 of the 42 text figures. It deals with a series of human embryos, as illustrating "The Development of the Limbs, Body-wall, and Back, in Man," and is a joint production by Drs. C. R. Barden and W. H. Lewis, of Baltimore. It is carefully written, and of the illustrations no praise can be too high. But we deplore the fact that, beyond the more exact determination of the actual period at which some of the important constituents of the developing nervous system and parts of the fore- and hind-limbs are first differentiated, there is nothing either recorded or delineated in it which is new. As a chapter for a text-book it would be well-nigh ideal; but in a journal devoted to records of research and new observations it is out of place and does but hamper the way.

We wish no disrespect to the authors, for if, as we assume, in providing the positively magnificent illustrations, they have but availed themselves of the condition set forth in the editorial advertisement, "that the cost of more expensive plates must be borne in part by the authors," we would rather tender them our hearty thanks. While, however, we would thus appraise their enterprise and artistic taste, we are still of opinion that, if our surmise is correct, both these and their enthusiasm have been misapplied; for if we are to proceed on these lines, the danger, at present obvious enough in all departments of anatomical